Viruses outnumber prokaryotes in marine subsurface sediments

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The marine subsurface comprises nutrient-depleted and energy-limited environments, exhibiting a high microbial abundance and diversity. Sources of organic carbon in deeply buried sediments are vanishingly small and the long-term survival of indigenous microorganisms is still enigmatic. Cells are capable to live under energy-limited conditions but controlling factors for cell death in marine subsurface environments remain largely unidentified. Here, the question arises if viruses are controlling prokaryotic mortality. For this habitat, the general role of bacteriophages as a potential driver of microbial ecology was barely addressed so far [1, 2, 3]. Phages are known to contribute to carbon cycling and to control microbial communities in various marine habitats. Furthermore, they mediate horizontal gene transfer and thus, supporting the adaptation of host organisms to environmantal conditions.

We found phages to be highly abundant even in deep, ancient (~14 Ma old) and the most oligotrophic subsurface sediments of the world´s oceans (South Pacific Gyre). The number of viruses always exceeded that of prokaryotic cells and varied by several orders of magnitude within a comprehensive set of globally distributed subsurface sediments. Abundances of phages and cells generally decreased with sediment depth. However, an increasing virus-to-cell ratio is constituted in deeper and more oligotrophic layers, exhibiting values of up to 225 in the deep subsurface of the South Pacific Gyre. The presence of phages in enormous numbers suggests their impact on prokaryotic communities as controlling factor for cell abundance, diversity and life in the marine deep biosphere.

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Analysis of internal dynamics in a deep subduction channel

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The spatial-temporal scales of tectonic fragmentation and mixing during the evolution of subduction channels need to be resolved. Current thinking nourished by numerical models requires critical testing against data on HP-terrains. However, deciphering natural archives of the time-integrated record of structural and metamorphic processes demands an approach that combines observations from μm- to km-spatial scales.

Our approach is shown for a case study in the Sesia Zone, a classic eclogite facies terrain in the Western Alps, Italy. The control provided by regional structural maps was extended from the meso- to the microscopic scale. Painstaking petrographic documentation was required to recognize the several generations of HP-assemblages, mineral inclusions, textural and chemical domains and to relate these in (relative) time. *in situ* dating by robust Th-U-Pb mineral chronometry was combined with thermobarometry; this allowed several stages of HP-tectonics to be discerned and metamorphic reactions to be related to the polyphase deformation. PTDt-sequences thus derived were mutually consistent for individual sample suites, but substantial differences emerged for different parts of the Sesia Zone. Their regional distribution indicates that tectonic slices (previously unrecognized) exist. Differential mobility between these lasted >20 Myr and one terrane experienced pressure cycling (ΔP ~5 kbar). These dynamics had escaped the many previous studies and predate what has until recently been accepted as "the age" of the Sesia HP-belt, i.e. ~65 Ma.

The major challenge remains to quantify the typical mobility of fragments within this subduction channel. In the Sesia Zone fragmentation at micro- to mesoscopic scale is very common in the eclogitic micaschists; in gneissic parts mylonites are not rare. Yet estimating the total amount of strain or the magnitude of displacements between adjacent units is difficult beyond the deca- to hectometer scale of outcrops. Our ongoing regional work aims to provide better constraints on the geometry and size of mobile tectonic slices, again using the petrochronological approach described.

At this stage of our study, it is clear that (km-size) tectonic fragments were independently mobile within the subduction channel, with vertical cycling rates of 2-3 mm/a.

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